

-57-

CLAIMS

1. A spacecraft for orbiting a sunlit celestial body (300), the spacecraft including a thermal radiator surface (11,12,1804, 2121, 2721) for radiating heat from the spacecraft into space, and a sun ray blocker device (581, 582, 681, 682) mounted on said spacecraft for shielding said thermal radiator surface (11,12,1804, 2121, 2721) from rays of sunlight, characterised in that said sun ray blocker device (581, 582, 681, 682) includes at least one sun blocker component (111, 112, 271, 301, 411,511, 611, 811,921, 951, 1800, 2100, 2700, 3100, 3200), said sun blocker component being locatable, in an operational configuration, on a sun line from said thermal radiator surface (11,12,1804, 2121, 2721) and being of suitable shape, size, and orientation for placing in shadow up to the whole of said thermal radiator surface (11,12,1804, 2121, 2721) from sunlight, said sun blocker component having a surface (111a, 112a) intended to face the Sun in use and an opposed surface (111b, 112b) intended to face away from the Sun in use, said sun blocker component (111, 112, 271, 301, 411,511, 611, 811,921, 951, 1800, 2100, 2700, 3100, 3200) being adapted for achieving a high radiation view factor from the thermal radiator surface (11,12,1804, 2121, 2721) to deep space by means including thermal insulation material located between the sun-facing surface (111a, 112a) and the opposed surface (111b, 112b) for restricting heat flow through said sun blocker component (111, 112, 271, 301, 411,511, 611, 811,921, 951, 1800, 2100, 2700, 3100, 3200) between said sun-facing surface (111a, 112a) and said opposed surface (111b, 112b).
2. A spacecraft as claimed in claim 1, wherein the sun-facing surface (111a, 112a) is thermally insulated from

-57/1-

the opposed surface (111b, 112b) by multi-layer insulation (MLI).

- a
3. A spacecraft ~~as claimed in any of the preceding~~
5 ~~claims~~!, wherein said sun blocker component (111, 112, 271, 301, 411, 511, 611, 811, 921, 951, 1800, 2100, 2700, 3100, 3200) is further adapted for achieving a high radiation view factor from the thermal radiator surface (11,12,1804, 2121, 2721) to deep space by means including
10 a region of said opposed surface (111b, 112b) being adapted to lie, in an operational configuration, substantially in a plane for limiting a radiation view factor from said opposed surface (111b, 112b) to said opposed surface (111b, 112b).
- a
- 15 4. A spacecraft ~~as claimed in any of the preceding~~
~~claims~~, wherein said sun blocker component (111, 112, 271, 301, 411, 511, 611, 811, 921, 951, 1800, 2100, 2700, 3100, 3200) is further adapted for achieving a high radiation view factor from the thermal radiator surface
20 (11,12,1804, 2121, 2721) to deep space by means including a region of said opposed surface (111b, 112b) being adapted to face, in an operational configuration, at an angle away from said thermal radiator surface (11,12,1804, 2121, 2721) for limiting reflection by said
25 sun blocker component (111, 112, 271, 301, 411, 511, 611, 811, 921, 951, 1800, 2100, 2700, 3100, 3200) of thermal energy from said thermal radiator surface (11,12,1804, 2121, 2721) back to said thermal radiator surface (11,12,1804, 2121, 2721). *claim 1*
- a
- 30 5. A spacecraft ~~as claimed in any of the preceding~~
~~claims~~, wherein said sun blocker component (111, 112, 271, 301, 411, 511, 611, 811, 921, 951, 1800, 2100, 2700,

-57/2-

3100, 3200) is further adapted for achieving a high radiation view factor from the thermal radiator surface (11,12,1804, 2121, 2721) to deep space by means including a dimension and/or a shape of said sun blocker component (111, 112, 271, 301, 411,511, 611, 811,921, 951, 1800, 2100, 2700, 3100, 3200), in an operational configuration, serving to limit a corresponding geometric radiation view factor from said thermal radiator surface (11,12,1804, 2121, 2721) to deep space.

6. A spacecraft ~~as claimed in any of the preceding claims~~, wherein an effective radiation view factor for thermal radiation from the thermal radiator surface (11,12,1804, 2121,2721) to deep space is significantly greater than a corresponding geometrical radiation view factor to deep space, and in particular, for a geostationary spacecraft where the geometrical radiation view factor to deep space is 0.65, the effective radiation view factor to deep space is at least 0.87.

-58-

- a
- a
7. A spacecraft ^{claim 1} ~~as claimed in any of the preceding~~
~~claims~~, wherein the sun-facing surface (111a, 112a) has
5 a low solar energy absorptivity of less than 0.5.
8. A spacecraft ^{claim} ~~as claimed in any of the preceding~~
~~claims~~, wherein the sun-facing surface (111a, 112a)
includes a solar cell panel for supplying electrical
power to the spacecraft.
- 10 9. A spacecraft ^{claim 1} ~~as claimed in any of the preceding~~
~~claims~~, wherein the sun-facing surface (111a, 112a) has a
high thermal emissivity of higher than 0.7.
10. A spacecraft ^{claim} ~~as claimed in any of the preceding~~
~~claims~~, wherein the sun ray blocker device (582, 681,
15 682) is adapted for a reconfiguration involving movement
between a stowed, non-operative position and a deployed,
operative position after launch of said spacecraft.
11. A spacecraft ^{claim 1} ~~as claimed in any of the preceding~~
~~claims~~, wherein the sun ray blocker device (581, 582,
20 681, 682) includes an attachment arm (207, 205, 430, 230,
1805, 1905, 2137, 2708, 2709) for attaching the sun
blocker component (111, 112, 271, 301, 411, 511, 611,
811, 921, 951, 1800, 2100, 2700, 3100, 3200) to the
spacecraft.
- a
- a
- a
- a

-59-

12. A spacecraft as claimed in claim 11, wherein the attachment arm (207, 205, 430, 230, 1805, 1905, 2137, 2708, 2709) is attached by a hinge means (203, 309, 406, 606, 306, 1812, 2138, 2710, 2711) to the sun blocker component (111, 112, 271, 301, 411, 511, 611, 811, 921, 951, 1800, 2100, 2700, 3100, 3200) and/or by a second hinge means (215, 217, 407, 507, 607, 307, 1813, 1913, 2136, 2702, 2703) to the spacecraft.
13. A spacecraft ~~as claimed in any of claims 10 to 12,~~ wherein the sun ray blocker device (581, 582, 681, 682) includes a motor for moving said sun ray blocker device between the stowed position and the deployed position.
14. A spacecraft ~~as claimed in any of the preceding~~ ^{claim 1} ~~claims,~~ wherein locating means are provided for locating the sun ray blocker device (581, 582, 681, 682) with respect to the thermal radiator surface (11, 12, 1804, 2121, 2721) which includes adjustment means to maintain up to the whole of said thermal radiator surface in shadow irrespective of changes in the attitude and/or orbital position and/or orbit of the spacecraft during normal operations.
15. A spacecraft as claimed in claim 14, wherein the adjustment means includes a variable length attachment

-59/1-

arm (2130, 2730) for attachment of the sun blocker component to the spacecraft.

⁵ 16. A spacecraft as claimed in claim 15, wherein the attachment arm is a scissors arm (2730).

17. A spacecraft as claimed in claim 15, wherein the attachment arm (2130) is formed of articulated portions (2132, 2134, 2137) which may be mutually articulated

-60-

during rotation to vary an effective length of the attachment arm.

18. A spacecraft as claimed in claim 14, wherein the adjustment means includes carriage means (1801, 1902, 1906, 1907, 2001) for carrying the sun blocker component (1800) and transport means (1802, 1830, 1903, 1930, 2002, 2003, 2030) for moving the carriage with respect to the spacecraft.
19. A spacecraft as claimed in claim 18, wherein the transport means includes guide means (1802) and the carriage means (1801) includes drive means (1830) to drive the carriage along the guide means.
20. A spacecraft as claimed in claim 18, wherein the transport means includes guide means (2002) and motive means (2003) that are external to and connected to the carriage means (2001), the external motive means being driven by drive means (2030) to move the carriage means along the guide means (2002).
21. A spacecraft as claimed in claim 18, wherein the carriage means includes an annulus (1902) rotatable in a circular path defined by bearing means (1903) the annulus being driveable by drive means (1930) to move the carriage along the path defined by the bearing means.
22. A spacecraft ~~as claimed in any of claims 14 to 21,~~ having a solar cell array (100, 101, 225, 408, 2000) adapted for tracking movements of the Sun relative to the spacecraft, wherein the adjustment of the location of the sun ray blocker device (581, 582, 681, 682) in relation to the thermal radiator surface (11, 12, 1804, 2121, 2721) is synchronised with the

-60/1-

23. A spacecraft as claimed in claim 22, wherein the sun ray blocker device (581, 582, 681, 682) is mounted on the solar cell array (100, 101, 225, 408) or on means carrying said solar cell array.

a 5 24. A spacecraft ~~as claimed in claims 22 or 23~~, wherein the solar cell array is adapted for tracking the movement of the Sun by rotation of the solar cell array about an axis of rotation of the solar cell array (100, 101, 225, 408, 2000) such

-61-

that the sun blocker component (111, 112; 271; 301; 411; 511; 611; 811; 921; 951; 2100; 2700; 3100; 3200) also rotates about said axis of rotation of the solar cell array.

- 5 25. A spacecraft as claimed in claim 24, wherein the thermal radiator surface (11, 12, 2121, 2721) is orthogonal to the axis of rotation of the solar cell array so that the sun blocker component (111, 112; 271; 301; 411; 511; 611; 811; 921; 951; 2100; 2700; 3100; 10 3200) rotates about an axis normal to the thermal radiator surface.

26. A spacecraft *as claimed in any of* ~~as claimed in any of~~ claims 23 ~~to 25~~, wherein the adjustment means for attachment of the sun blocker component (2100, 2700) to a solar cell array 15 assembly (2131, 2701) are such that a distance between the sun blocker component and the solar cell array assembly may be varied during rotation of the sun blocker component.

27. A spacecraft as claimed in ~~any of claims 14 to 26~~, wherein the sun blocker device (581, 582, 681, 682) 20 tracks the movement of the sun by rotation of the sun blocker device about an axis of rotation of the sun blocker device which is orthogonal to the thermal radiator surface (11, 12, 1804, 2121, 2721) so that the sun 25 blocker component (111, 112, 271, 301, 411, 511, 611, 811, 921, 951, 1800, 2100, 2700, 3100, 3200) rotates about an axis normal to said thermal radiator surface.

-61/1-

- a*
a
28. A spacecraft, as claimed, ^{*claim 1*} ~~in any of the preceding~~
~~claims~~, wherein means (929, 931, 925, 927, 955, 957) are
provided for adjusting the form and/or size of the sun
5 blocker component (111, 112, 271, 301, 411, 511, 611,
811, 921, 951, 1800, 2100, 2700, 3100, 3200).

-62/2-

a

29. A spacecraft as claimed ~~in any of the preceding claims,~~
including control means for controlling the spacecraft so
as to maintain an angle between a sun line and the

-62/2/1-

thermal radiator surface (11,12, 1804, 2121, 2721) below a predetermined angle by adjustment of the orbit and/or attitude of the spacecraft in use.

30. A spacecraft as claimed in claim 29, wherein the
5 predetermined angle is 60 degrees.
31. A spacecraft as claimed ~~in claim~~ 29 ~~or 30~~, wherein the control means is adapted to maintain the thermal radiator surface (11,12, 1804, 2121, 2721) substantially parallel to a plane of an orbit of the spacecraft.
- 10 32. A spacecraft as claimed ~~in any of claims 29 to 31~~, wherein the control means is adapted to maintain the spacecraft in a sun synchronous orbit.
33. A spacecraft as claimed ~~in any of claims 29 to 31~~, wherein the control means is adapted to maintain the
15 spacecraft in an equatorial or low-inclination orbit.